Chapter Four: Contents

(Portland Emissions– 10 December 2002 – LA-UR 01-5715 – Portland Study Reports)

Chapter Four—Portland Emissions

1. Generation of Portland Emissions

1.1 Microsimulation Setup

A 24-hour simulation run was made with the TRANSIMS Traffic Microsimulator for collection of output to run emissions modules.

All file names mentioned within this section are in reference to the */home/transims/CaseStudy3/scenarios/allstr* directory. The configuration file used to run the microsimulation and collect output was *config_files/allstr_CA_MS19.emissions.cfg*; the default configuration file was *allstr.emissions.cfg* (see Volume Seven (*Appendix: Scripts, Configuration Files, Special Travel Time Functions*) Chapter Fourteen (*MS-E*). These configuration files allowed for the collection of output needed for processing emissions and not the usual microsimulation output. The plans used were the RS19 set.

The Network was defined by the following configuration file keys:

```
NET_NODE_TABLE                  Node 20010806.tbl
NET_LINK_TABLE                  Link 20010913.tbl
NET_PARKING_TABLE               Parking_MICROSIM.20010810.tbl
NET_ACTIVITY_LOCATION_TABLE     Activity_Location.20010806.tbl
NET_TRANSIT_STOP_TABLE          Transit_Stop.tbl
NET_PROCESS_LINK_TABLE          Process_Link.tbl
```

Output was collected on the links found in the *data/allstr.links* file.

Other microsimulation configuration file keys used include:

```
CA_SHORT_SOAK_TIME                     600 # 10 minutes
CA_MEDIUM_SOAK_TIME                    1800 # 30 minutes
CA_LONG_SOAK_TIME                      9000 # 2.5 hours
OUT_SUMMARY_VELOCITY_MAX_DEFAULT       37.5
OUT_SUMMARY_VELOCITY_BINS_DEFAULT      5
OUT_SUMMARY_ENERGY_MAX_DEFAULT         105
OUT_SUMMARY_ENERGY_BINS_DEFAULT        7
OUT_SUMMARY_TIME_STEP_DEFAULT          3600
OUT_SUMMARY_SAMPLE_TIME_DEFAULT        1
OUT_SUMMARY_BOX_LENGTH_DEFAULT         30
```

1.2 Output from Microsimulation

There were eight output files collected. Three of the files were summary velocity output: auto, truck, and bus velocities. Velocity data was sampled every second and output every 3600 seconds (1 hour). Velocity data was collected for every 30-meter box (four cells) on every link in the *data/allstr.links* file regardless of whether there were vehicles in the boxes or not. Therefore, velocity output file sizes are not dependent on number of vehicles in the simulation. The microsimulation output the following velocity summary files: *summary.auto.vel*, *summary.bus.vel*, and *summary.truck.vel*

Four of the eight output files were energy summary output. Energy summary data was output every 3600 seconds (1 hour). Energy data is sampled when a vehicle of type `AUTO` enters a link. Energy data was collected for every link in the *data/allstr.links* file regardless of whether there were vehicles on the links or not. Therefore, energy output file sizes are not dependent on the number of vehicles in the simulation. The microsimulation output the following energy summary files: *summary.no.enr*, *summary.short.enr*, *summary.medium.enr*, and *summary.long.enr*.

The final output file was the traveler event file. Event data is collected as the specific events occur. The microsimulation collected begin-trip and end-trip events for vehicles of type `AUTO` only. The outputted traveler event file size depends on the number of vehicles starting and ending trips during the simulation. To keep the traveler event file size to a bare minimum, the following configuration file key settings were used:

```
OUT_EVENT_NAME_1        event
OUT_EVENT_TYPE_1        TRAVELER
OUT_EVENT_FILTER_1      VEHTYPE==1;STATUS @ [16900|19716|25860]
OUT_EVENT_SUPPRESS_1    TRAVELER;TRIP;LEG;ROUTE;STOPS;YIELDS;SIGNALS;TURN;STOPPED;
                        ACCELS;TIMESUM;DISTANCESUM;USER;ANOMALY;LINK;NODE;VSUBTYPE
```

The Traffic Microsimulator output the traveler event file *event.trv*.

1.3 Disk Usage of Traffic Microsimulator's Output Files

Table 1. Disk usage of the Traffic Microsimulator's output files.

File	Disk usage
summary.auto.vel	1363568794 bytes (1.36 GB)
summary.bus.vel	1336522121 bytes (1.34 GB)
summary.truck.vel	1337630845 bytes (1.34 GB)
summary.no.enr	122931708 bytes (123 MB)
summary.short.enr	204784954 bytes (205 MB)
summary.medium.enr	205324722 bytes (205 MB)
summary.long.enr	206360712 bytes (206 MB)
event.trv	180946944 bytes (181 MB)

Total disk usage for the microsimulation output was 5.4 GB.

1.4 Emissions Modules and Resulting Files

The configuration file *config_files/allstr_emissions_MS19.cfg* was used to run the emissions modules, and *allstr.emissions.cfg* was used as the default configuration file.

Refer to the configuration files in Volume Seven (*Appendix: Scripts, Configuration Files, Special Travel Time Functions*) Chapter Sixteen (*EM-F*).

1.4.1 Emissions Modules/Scripts

Table 2. Emissions modules/scripts.

Modules/Script	Usage
ConvertVELfile	autos and trucks, then for buses
ConvertENRfile	
EmissionsEstimator *distribVELfile* *RunLDVEmissions* script that runs *EmissionsEstimator* *combineEmissions*	for autos
EmissionsEstimatorHDV	trucks, then buses
ConvertTRVfile	
EvaporativeEstimator	

1.4.2 Disk Usage for Postprocessed and Final Emissions Files

Table 3. Disk usage for postprocessed and final emissions files.

File	Disk Usage
velocity.auto.out	1587534736 bytes (1.6 GB)
velocity.bus.out	86163010 bytes (86 MB)
velocity.truck.out	178715776 bytes (179 MB)
energy.long.out	309017763 bytes (309 MB)
energy.medium.out	309017763 bytes (309 MB)
energy.no.out	309017763 bytes (309 MB)
energy.short.out	309017763 bytes (309 MB)
emissions.auto.out	1164927839 bytes (1.2 GB)
emissions.bus.out	61385724 bytes (61 MB)
emissions.truck.out	138644975 bytes (139 MB)
OperatingEvapEmis.dat	642742145 bytes (643 MB)
StationaryEvapEmis.dat	87556751 bytes (88 MB)

The total disk space used for postprocessed and final emissions files was 5.3 GB

1.4.3 Run Time of Emissions Modules

Table 4. Run time of emissions modules.

Emissions module	Run time
ConvertVELfile for autos & trucks	60 minutes
ConvertVELfile for buses	24 minutes
ConvertENRfile	25 minutes
EmissionsEstimator for LDV (Replaced by) *distribVELfile* for 24 files *RunLDVEmissions* on 24 files *combineEmissions* on 24 files	34.5 hours 10 minutes 2 hours 9 minutes 8 minutes
EmissionsEstimatorHDV for trucks	10 minutes
EmissionsEstimatorHDV for buses	5 minutes
ConvertTRVfile	4 minutes
EvaporativeEstimator	50 minutes

The total running time of emissions processing after replacing the *EmissionsEstimator* step with *distribVELfile*, *RunLDVEmissions*, and *combineEmissions* on 24 CPUs took four hours. This was due to the fact that some steps were overlapped.

1.5 Problems

The *EmissionsEstimator* for autos took 34.5 hours to run. Because of this lengthy time, the *emissionsEstimator.C* code was modified to accept another optional argument that is an extension to the inputted velocity file and the outputted emissions file. Two new codes, *distribVELfile* and *combineEmissions*, were written along with a new script: *RunLDVEmissions*.

Usage:

```
distribVELfile <inputfilename> <#outputFiles> <startTime> <endTime>
runLDVEmissions <config file> <# files>
combineEmissions <baseFilename> <#files>
```

The velocity file was at first split into 12 individual files and processed separately. This still took 4.25 hours for the *EmissionsEstimator* processes started up from the *runLDVEmissions* script to finish. When the velocity files were distributed to 24 individual files (one for each timestep output), run time of *EmissionsEstimator* processes only took a little over two hours.

1.6 Summary

In summary, the running of the microsimulation and emissions modules required a total of 10.7 GB of disk space. The emissions module took four hours to run.

2. Analysis of Portland Emissions

The estimated emissions for Portland were quite low until 6:00 a.m., when the emissions rapidly rose to peak at 8:00 a.m. Fig. 1 reports the NO_x emissions for autos and light trucks, heavy trucks, and buses. The trucks peak later than the autos, and they don't have as large differences in emissions between the early morning hours and the peak hours as do the autos and light trucks. Buses are a relatively small part of the total emissions.

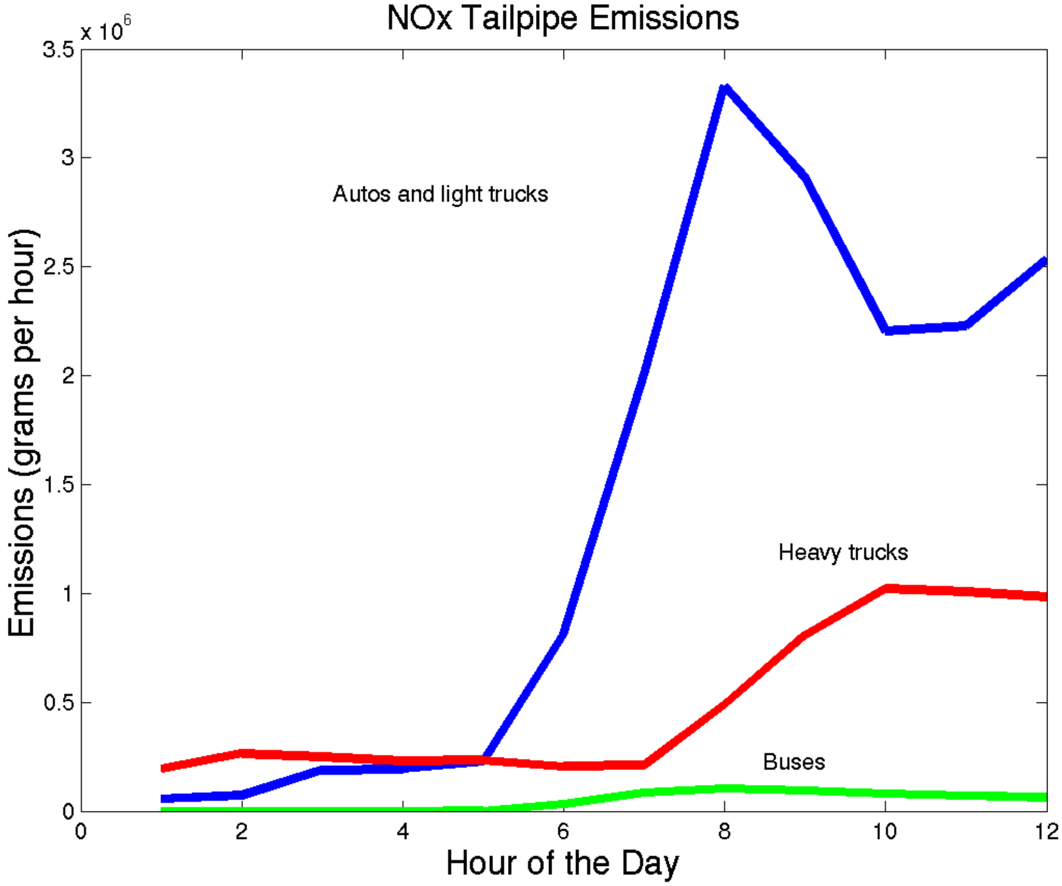

Fig. 1. Estimated NO_x emissions for mobile sources.

The CO emissions for the autos and light trucks show a similar pattern to those for NO_x emissions except that the trucks and buses have insignificant contributions.

Fig. 2 shows the behavior of the CO emissions. For hydrocarbons, trucks and buses are insignificant, but evaporative emissions do make a significant contribution.

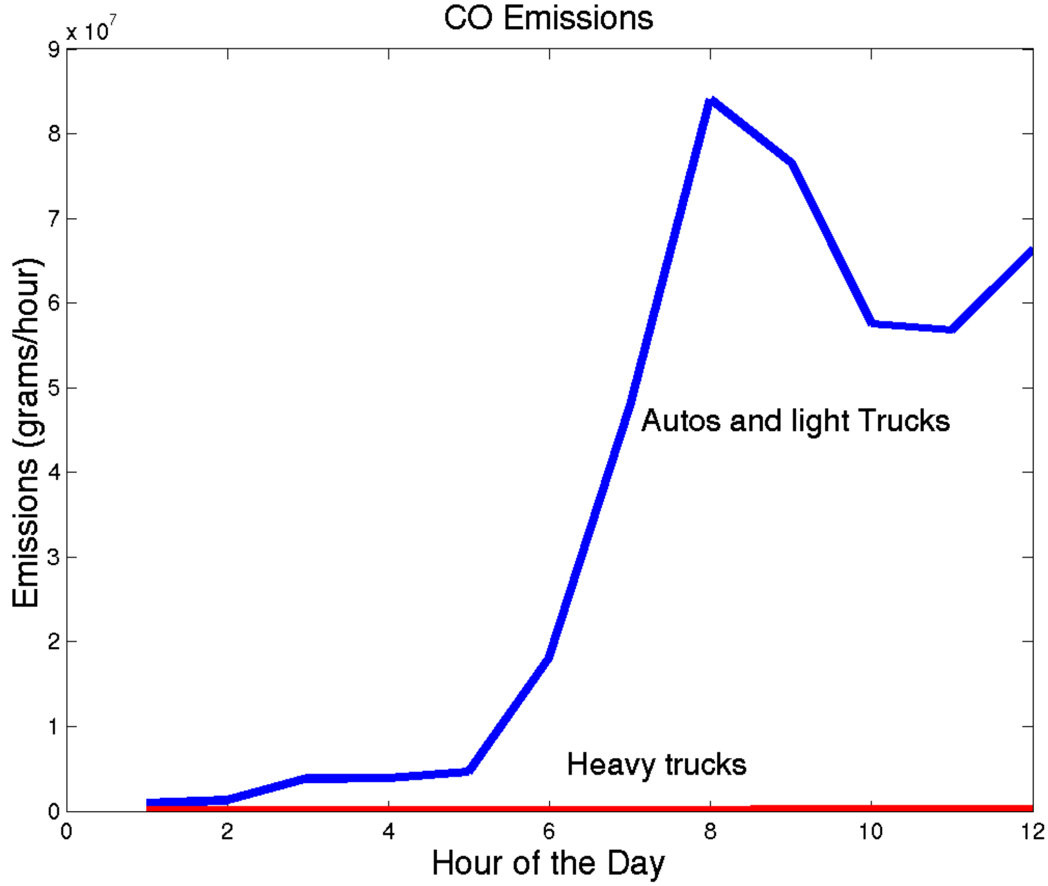

Fig. 2. Estimated CO emissions from mobile sources for the Portland Metropolitan area.

The operating evaporative emissions are similar to the stationary evaporative emissions. Fig. 3 displays the estimated hydrocarbon emissions.

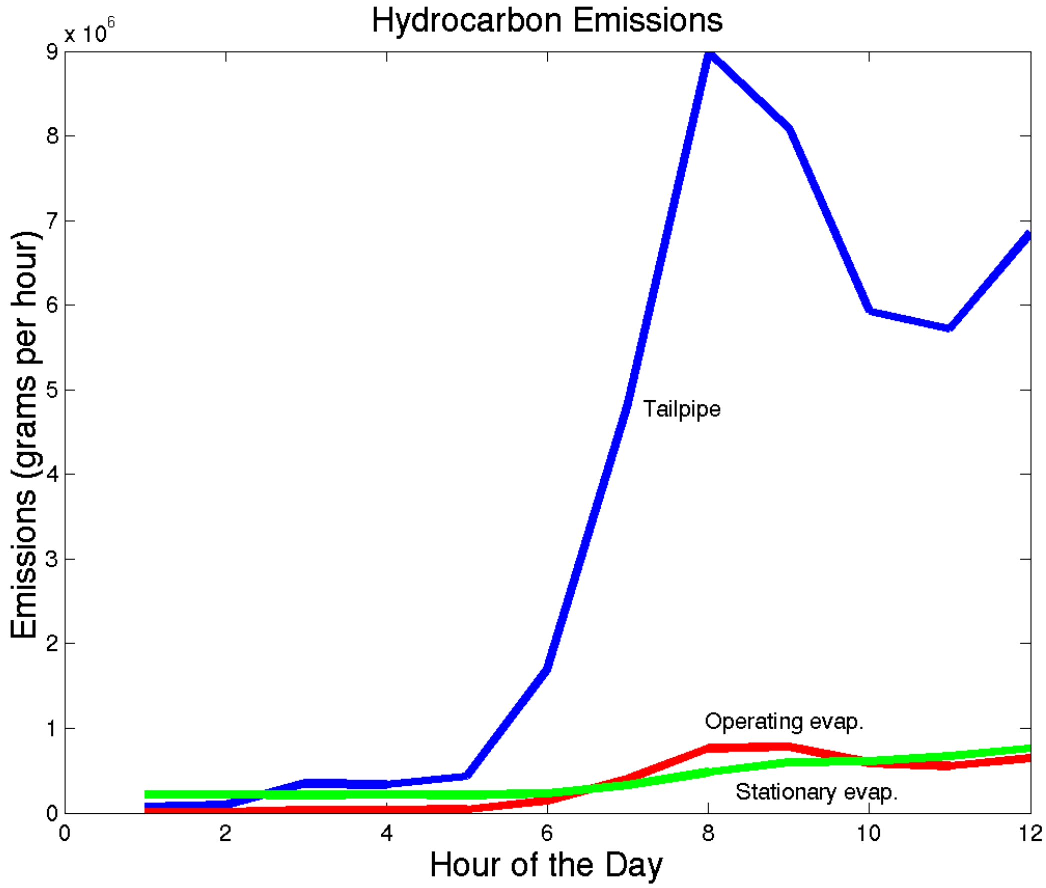

Fig. 3. Estimated hydrocarbon emissions from mobile sources in the Portland Metropolitan area.

Fuel consumption displayed in Fig. 4 shows a similar pattern to NO_x emissions.

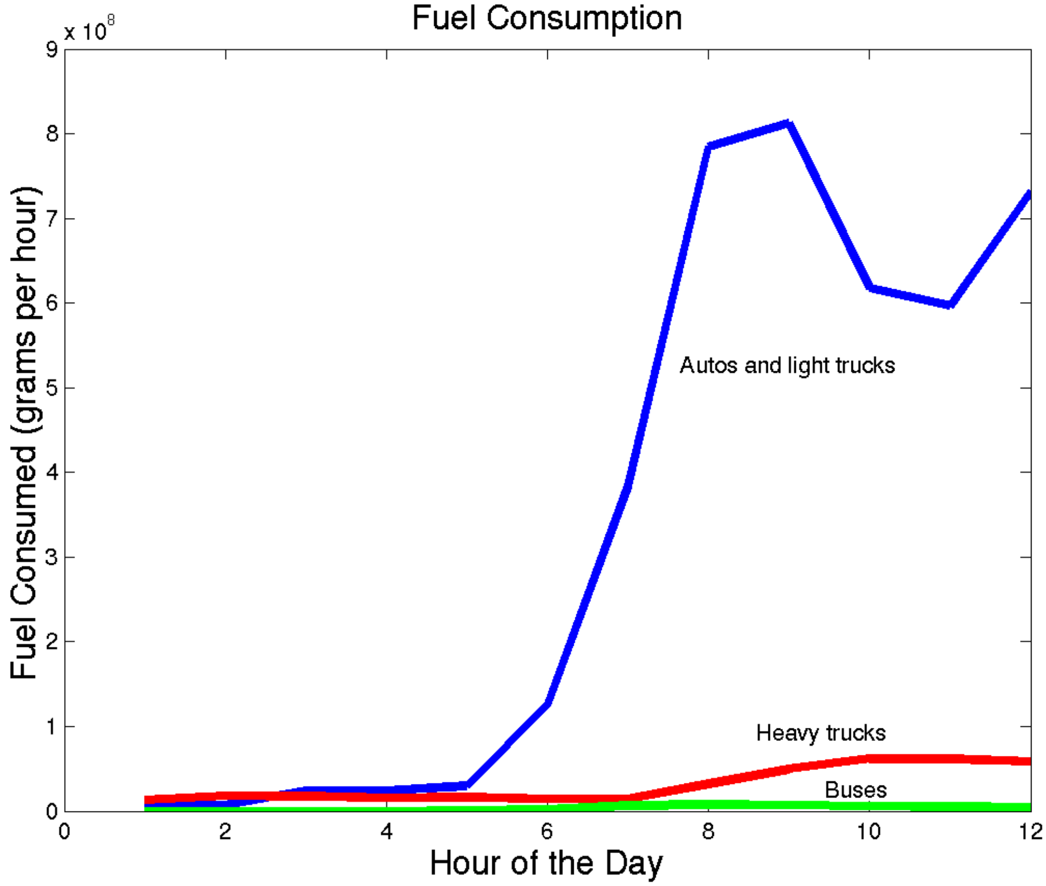

Fig. 4. Estimated fuel consumption for mobile sources in the Portland Metropolitan area.

The relative emission efficiency of transportation changes significantly through the day. In the early morning, the same flux of vehicles produces much lower emissions. Fig. 5 reports the relative emissions per unit flux for the morning hours. The average speed changes significantly during the morning hours, and the slower speeds are associated with much higher emissions per trajectory.

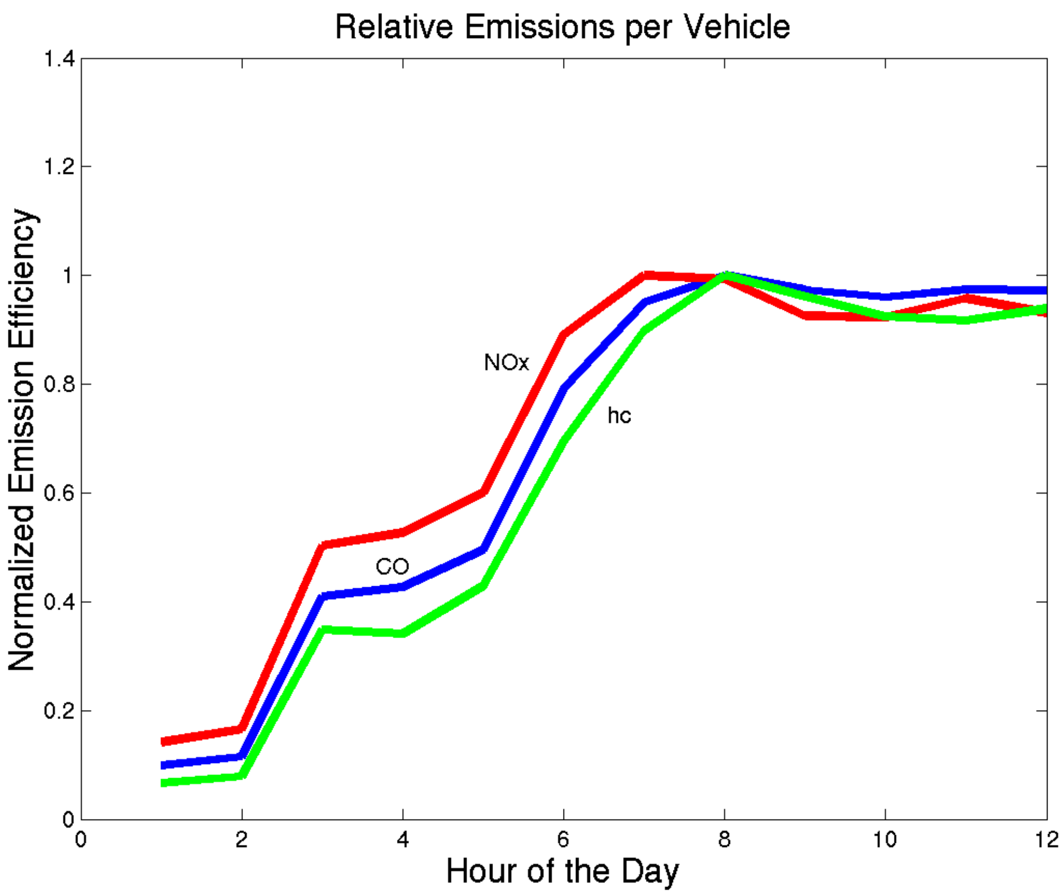

Fig. 5. Estimated relative emissions per vehicle for the Portland Metropolitan area.

Fig. 6 reports the average speeds over the morning hours.

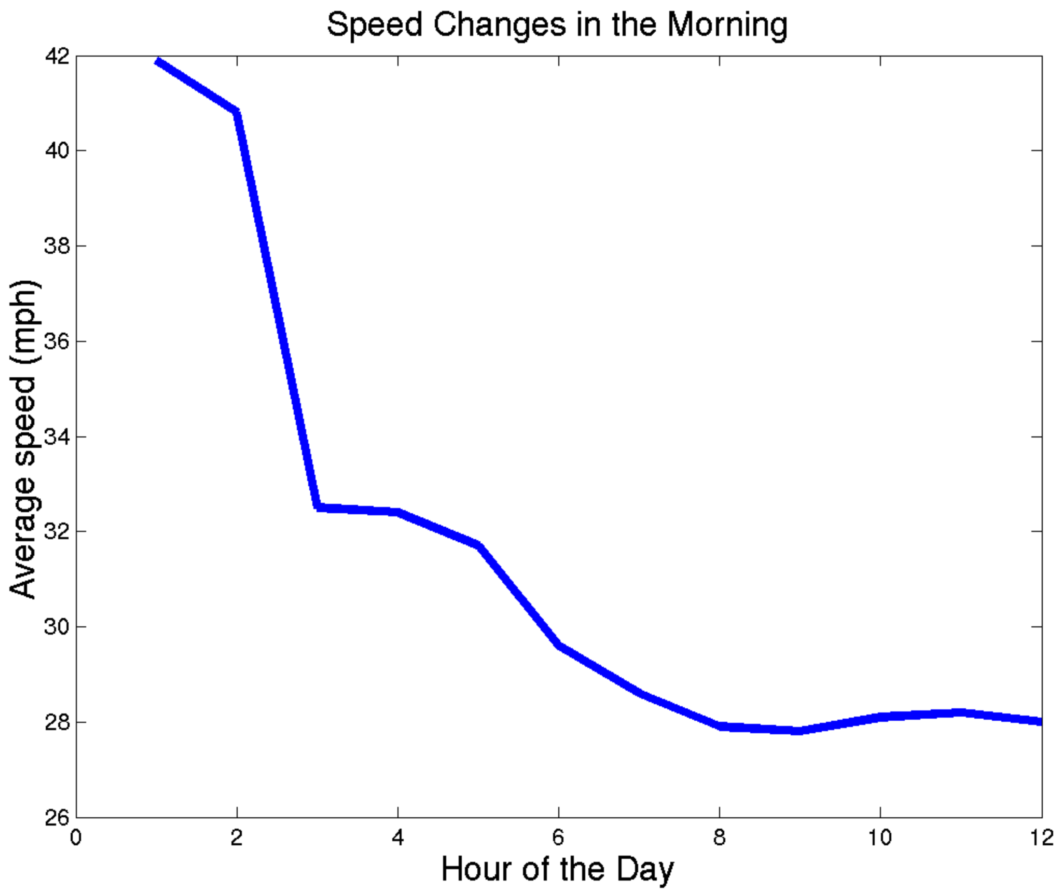

Fig. 6. Estimated average speeds in the Portland Metropolitan area.

Fig. 7 reports the spatial distribution of NO_x emissions at the peak hour of 8 a.m.

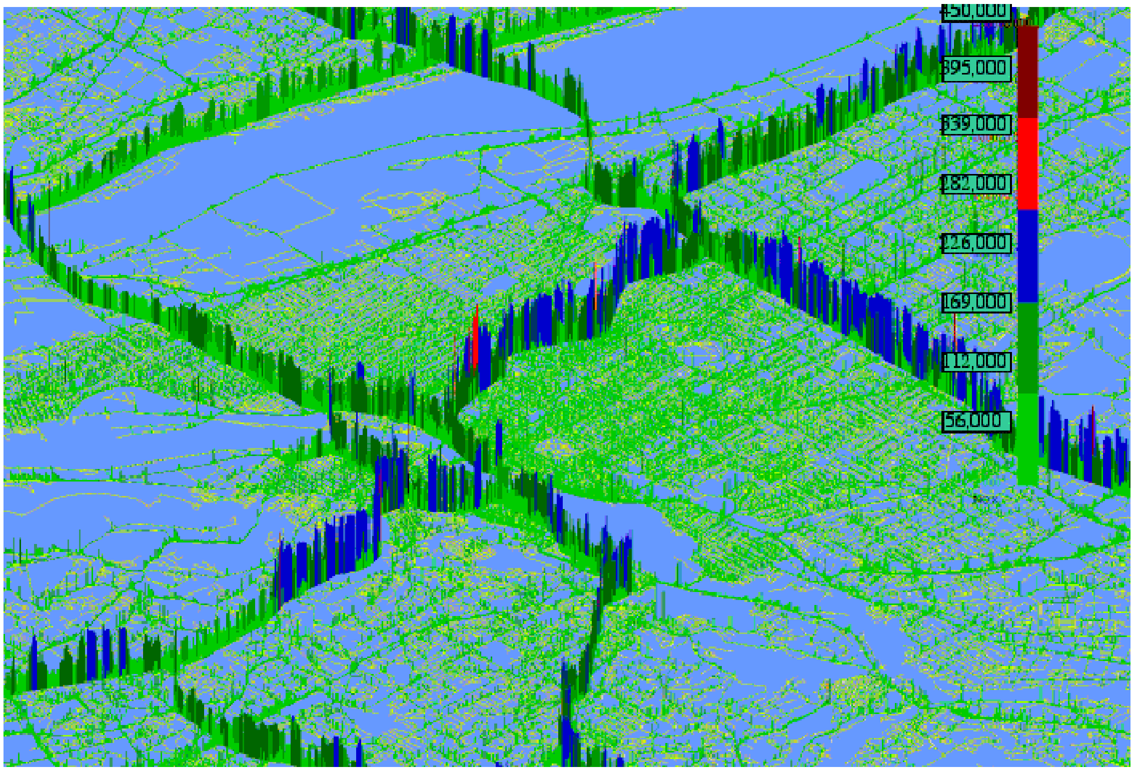

Fig. 7. Estimated spatial distribution of NO_x emissions at 8:00 a.m. Emissions are in milligrams per 30-meter segment per hour.

In this plot, the height is proportional to the emissions on the segment, and the color is also used as an indicator. Note that there will generally be two emission towers very close together representing traffic in each direction. There are many individual spikes. Many of these are probably artifacts of the technique used to calculate the emissions in intersections. In addition, since the Output Visualizer only displays information on links, the emissions from the intersection have been added to the first segment in each link. There are three significant factors that influence the emissions on the link:

1) the status of the engine and catalyst,

2) the number of vehicles passing through the link, and

3) the driving patterns on the link.

The highest emissions in Fig. 7 occur on freeways where the engines and catalysts are likely to be warm and, thus, the status is favorable to low rather than high emissions. Consequently, the engine status is not a major factor in the distribution of the highest emissions. We can examine the importance of the number of vehicles using the link by plotting emissions divided by a factor proportional to the number of vehicles traversing the link.

Fig. 8 describes the NO_x emissions normalized by the vehicle influx.

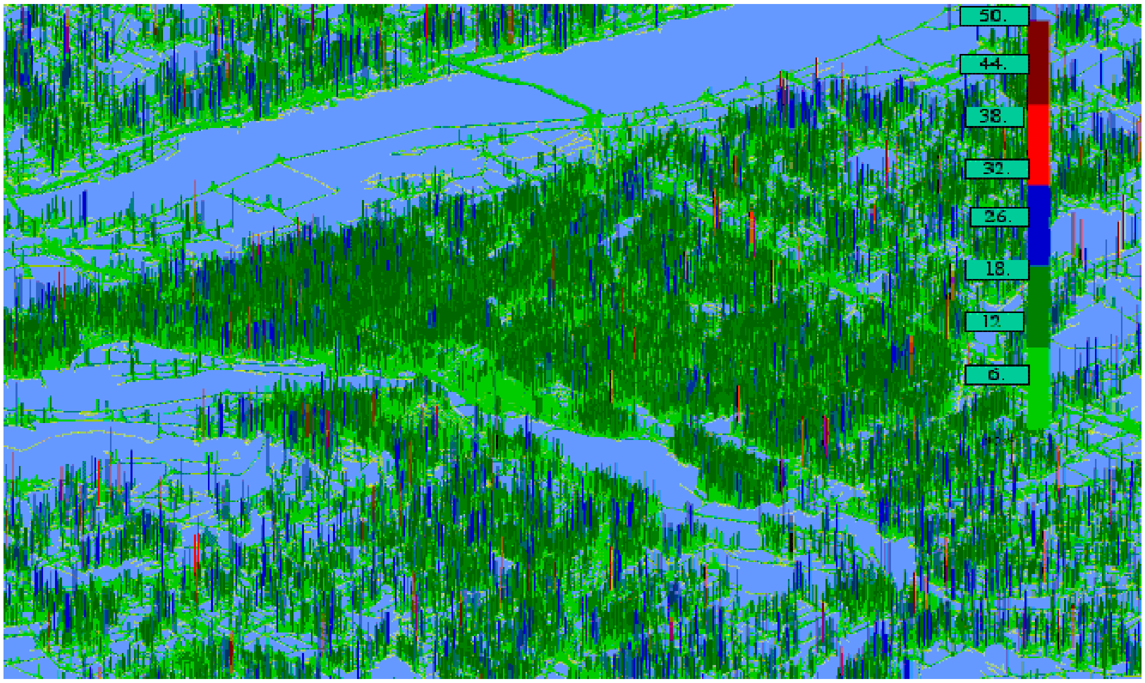

Fig. 8. NO_x emissions for 8:00 a.m. divided by a factor proportional to the number of trajectories passing through each segment.

In Fig. 8, the freeways appear as valleys within mountains of higher normalized emissions. Consequently, the dominant factor in the occurrence of high emissions on the freeways is the much larger numbers of vehicles using the freeways. The driving patterns on the freeways and their favorable engine/catalyst status produces lower emissions per vehicle than does the driving on adjacent streets and boulevards. There are relatively higher emissions on the freeways that may be associated with the driving patterns. For example, if we look at the clumping of red towers to the left of center in Fig. 7, we see significant changes in emissions along the freeway.

Fig. 9 provides a close-up view of this portion of the freeway as seen from a viewing point looking approximately from the south. The portion of interest is in the left center of Fig. 9.

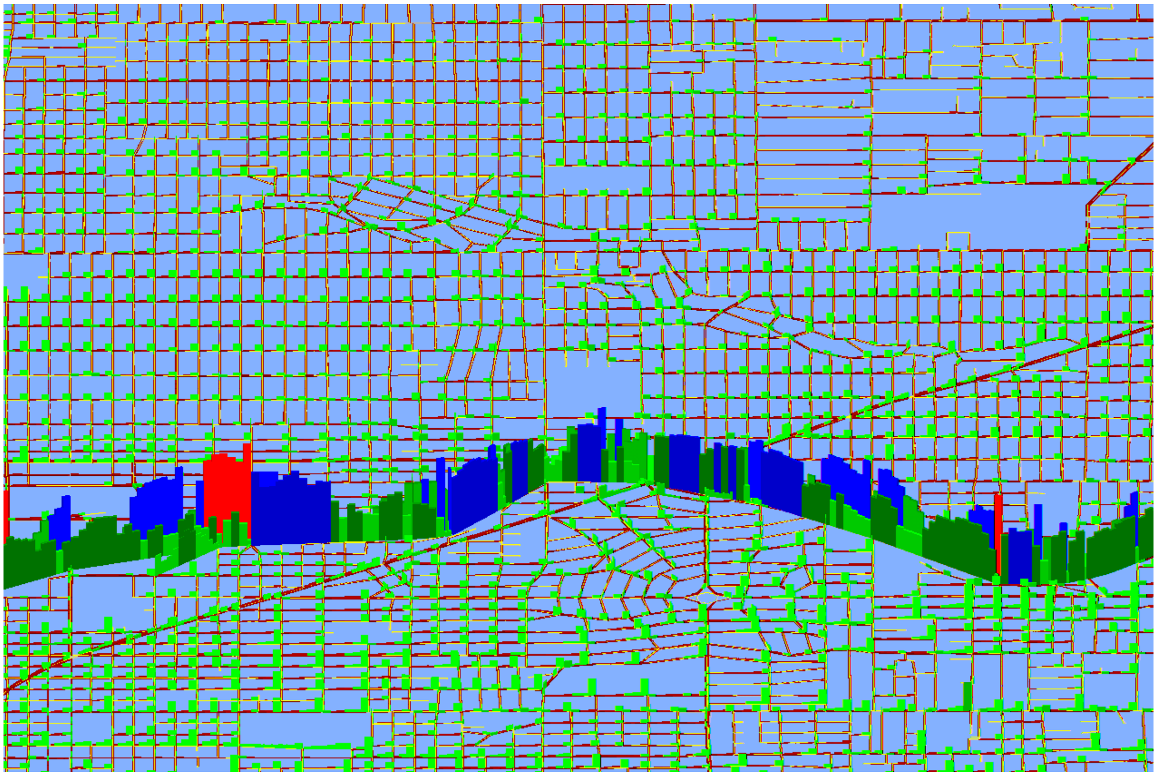

Fig. 9. Estimated NO_x emissions at 8:00 a.m. near I-84 and Sandy Blvd.

Fig. 10 reports the speeds for the same portion of the freeway, and we can see a prominent slowing of the freeway traffic on both sides of the freeway. The accelerating traffic from the bottleneck produces the large block of blue to the right of the bottleneck in Fig. 9, while traffic accelerating to the west produces the red grouping we noted in Fig. 7. It is also possible to see the emissions on the on-ramp from Northeast sixteenth street as cars approach the freeway from the southwest. The bottleneck on the north side of Interstate 84 probably is produced by a congested off-ramp.

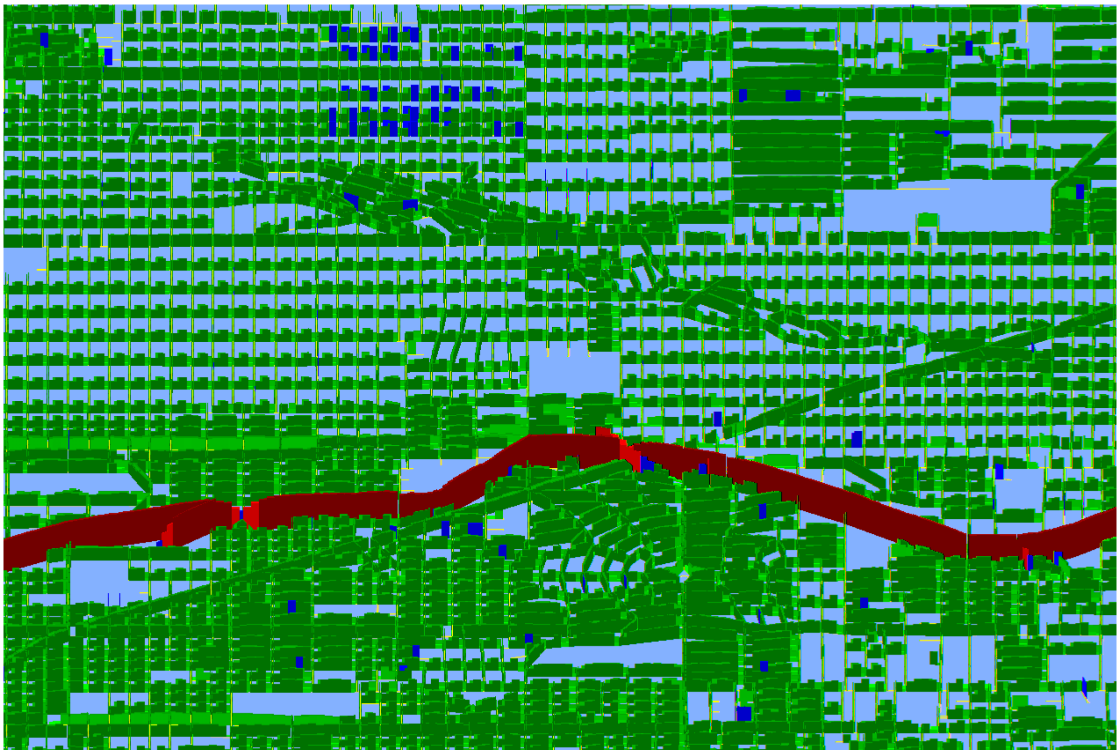

Fig. 10. Estimated speeds at 8:00 a.m. near I-84 and Sandy Blvd.

Fig. 11 reports the CO emissions and the pattern is very similar to that of Fig. 7.

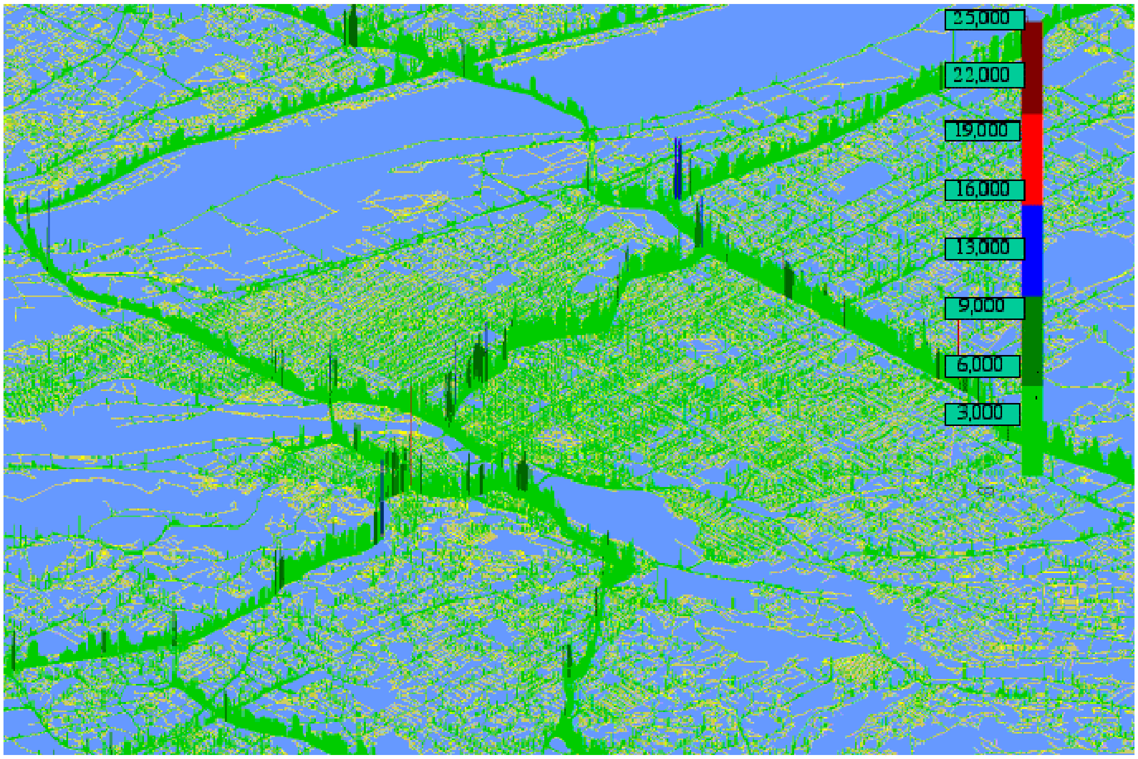

Fig. 11. Estimated spatial distribution of 8:00 a.m. CO emissions for the Portland Metropolitan Area. Emissions are expressed in grams per hour per 30-meter segment.

Fig. 12 reports the CO emissions divided by a factor proportional to the flux of vehicles through the link. Again the freeways contribute relatively low emissions on a per vehicle bias.

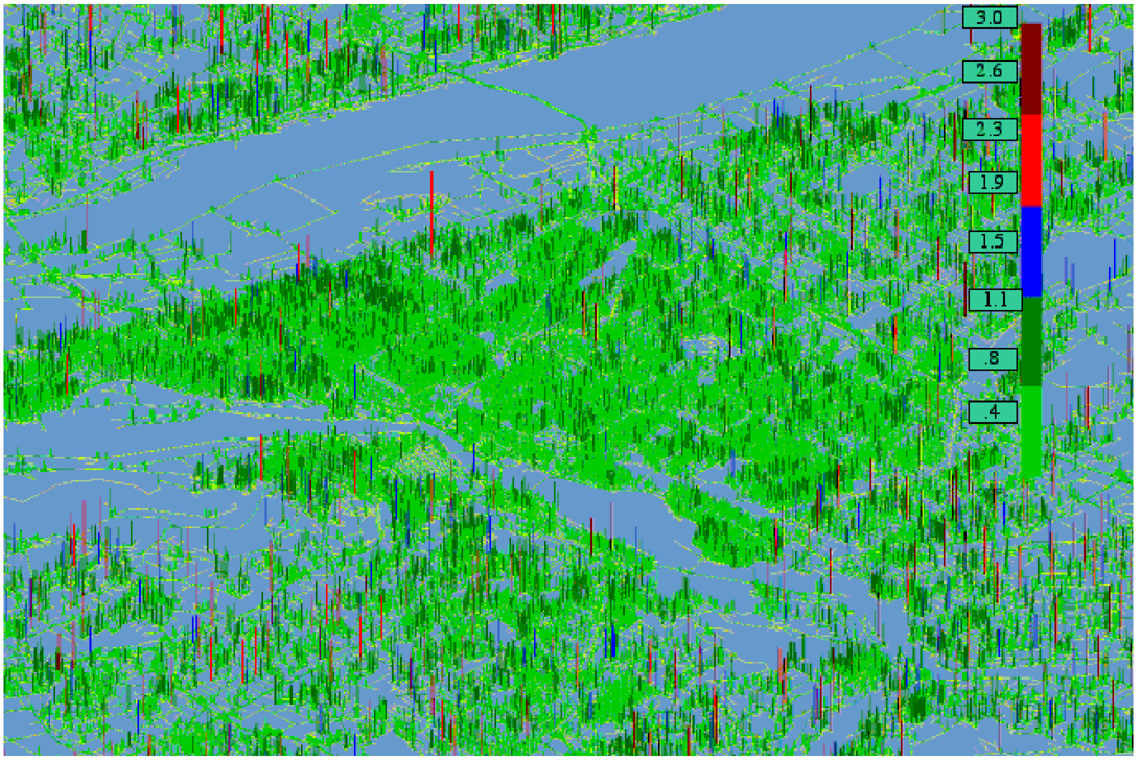

Fig. 12. Estimated spatial distribution of CO emissions divided by a factor proportional to the number of vehicle trajectories passing through each segment at 8:00 a.m.

Fig. 13 reports the hydrocarbon emissions for 8:00 a.m., and we see a pattern that is very similar to the NOx emissions of Fig. 7.

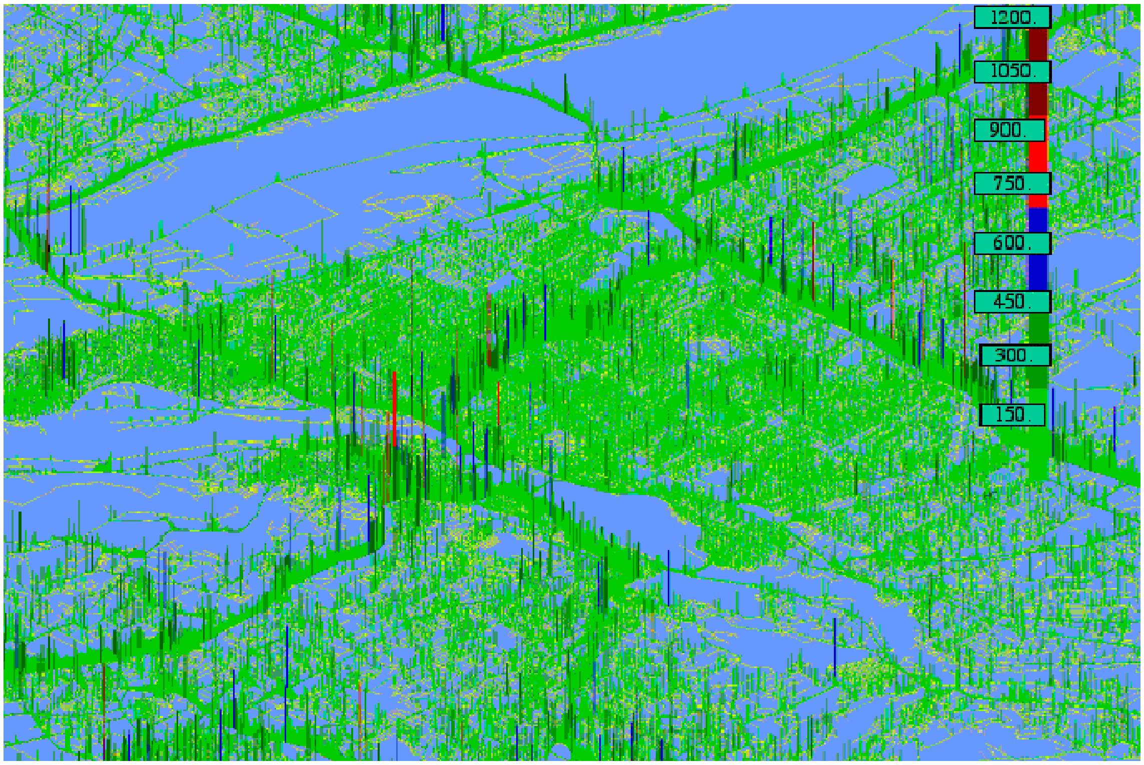

Fig. 13. Estimated spatial distribution of tailpipe hydrocarbon emissions at 8:00 a.m.. Emissions are in grams per 30-meter segment per hour.

Fig. 14 reports the hydrocarbon emissions divided by a quantity proportional to the number of trajectories traversing each link. Once again, the freeways show as areas with relatively low emissions per vehicle traversing a segment.

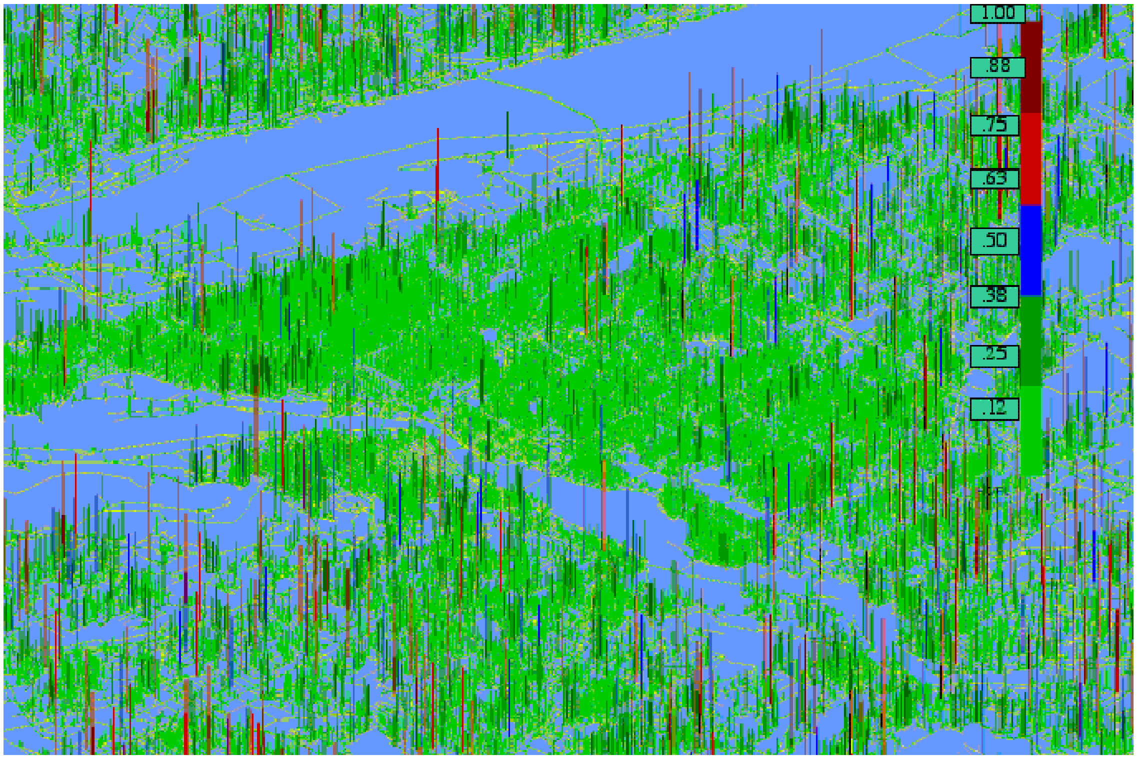

Fig. 14. Estimated hydrocarbon emissions divided by a factor proportional to the number of vehicles traversing a link at 8:00 a.m.